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BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Oversee the Resource Adequacy Program, Consider Program Refinements, and Establish Annual Local and Flexible Procurement Obligations for the 2016 and 2017 Compliance Years.	Rulemaking 14-10-010 (Filed October 16, 2014)

CALPINE CORPORATION PRELIMINARY PHASE 3 PROPOSAL

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December 16, 2016

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CALPINE CORPORATION PRELIMINARY PHASE 3 PROPOSAL

Pursuant to the *September 13, 2016 Assigned Commissioner and Administrative Law Judge's Phase 3 Scoping Memo and Ruling* and the *September 15, 2016 Email Ruling Correcting Schedule,* Calpine Corporation ("Calpine") submits the Calpine and Energy + Environmental Economics ("E3") Effective Load Carrying Capacity Proposal (the "Calpine/E3 Proposal"). The Calpine/E3 Proposal is contained herein as Attachment A.

Respectfully submitted,

/s/

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Attachment A

Calpine/E3 Proposal

Calpine/E3 ELCC Proposal

Contents

1. Introduction

This document presents the Calpine/E3 Proposal ("the proposal") for implementing the Effective Load Carrying Capability (ELCC) methodology to determine the net qualifying capacities (NQCs) of wind and solar resources for Resource Adequacy (RA) compliance in 2018 and beyond. It is critical to implement ELCC to accurately reflect the contribution of intermittent resources such as wind and solar to resource adequacy, especially as their penetrations increase.

Calpine/E3 believe that the proposal strikes an appropriate balance between the following criteria:

1. Ensuring reliability by accurately assessing the capacity contribution of the portfolio of wind and solar resources;
2. Ascribing NQCs that reflect the performance of specific resources;
3. Accounting for the impact of behind-the-meter resources on ELCC estimates;

4. Encouraging appropriate consideration of capacity value in the procurement of new renewable resources;
5. Minimizing the computational and compliance burdens associated with calculating NQCs.

The proposal involves three main steps:

1) Calculating the ELCC of the entire portfolio of wind and solar resources.
2) Disaggregating the Portfolio ELCC into Resource Class ELCCs.
3) Deriving NQCs for specific resources by allocating Resource Class ELCCs to specific resources in proportion to each resource's historical generation during a specific time window (or proxies in the case of resources with insufficient operating histories)

Using E3's RECAP model and load and renewable profiles developed by E3, the proposal yields following class-average NQCs for the 2018 RA year.[1]

Month	Wind avg. NQC/namplate MW	Solar avg. NQC/nameplate MW
Jan	15%	0%
Feb	18%	1%
Mar	10%	6%
Apr	17%	34%
May	23%	38%
Jun	25%	45%
Jul	22%	47%
Aug	14%	43%
Sep	9%	37%
Oct	10%	27%
Nov	9%	3%
Dec	14%	0%

Table 1. Average monthly NQC fractions for the wind and solar resource classes

As discussed in the conclusion, Calpine requests that the Commission implement critical elements of the proposal for the 2018 RA year and beyond.

1.1. Background

The California Public Utilities Commission ("Commission") and the California Independent System Operator (CAISO) have been using some version of the current exceedance methodology to determine how wind and solar resources count towards Resource Adequacy (RA) requirements since the 2010 RA year. The exceedance methodology captures the performance of resources in a set of predefined traditional peak hours. At its inception, the exceedance approach may have adequately captured the contribution of intermittent resources such as wind and solar to resource adequacy. As penetrations of these resources have increased, however, system conditions have changed so that hours later in the day are more critical to resource adequacy. This shift is likely to continue as penetrations of solar increase.

[1] Note that while Calpine/E3 relied on their own input assumptions and E3's ELCC model, RECAP, to formulate this proposal, the basic structure of the proposal could be implemented with the results of other ELCC models and/or input assumptions, potentially including those being used by Energy Division.

The Effective Load Carrying Capability (ELCC) methodology is capable of capturing this shift by focusing on the performance of resources in critical hours, whenever they happen to occur, rather than the set of predefined hours that are the focus of the current exceedance methodology.

In recognition of the importance of maintaining reliability by accurately quantifying how intermittent renewables contribute to resource adequacy as the state increases its reliance on renewables, state law requires the use of the ELCC methodology. In particular SBX1-2, the bill that expanded California's renewable portfolio standard (RPS) to 33%, modified the Public Utilities Code to require that the CPUC:

> *…determine the effective load carrying capacity of wind and solar energy resources on the California electrical grid. The commission shall use those effective load carrying capacity values in establishing the contribution of wind and solar energy resources toward meeting the resource adequacy requirements established pursuant to Section 380.*[2]

Since SBX1-2 was passed in 2011, ELCC has yet to be implemented. While the Commission has acknowledged the theoretical benefits of ELCC and its legal obligation to implement ELCC, it has expressed concerns about the feasibility and accuracy of the one somewhat complete ELCC proposal that it has considered.[3]

This proposal addresses the concerns that the CPUC raised in previously rejecting an ELCC proposal. In particular, it provides a method to estimate and assign resource-specific monthly ELCC-based NQCs.

1.2. Benefits of ELCC

ELCC reflects a resource's contribution to system reliability. Because ELCC[4] is based on a rigorous, probabilistic analysis of reliability that encompasses the complete electric system, it is more accurate than time window approaches or other heuristics such as the exceedance methodology. Due to advances in computing power and the wider availability of system and renewables data, ELCC is now relatively easy to compute and has become the industry standard for evaluating capacity contribution of renewable resources.

ELCC captures two important impacts of increasing renewables penetrations on reliability, diversity and saturation. *Diversity* refers to the fact that increasing penetrations of a resource may shift the timing of reliability problems in a manner that actually enhances how another resource contributes to reliability.

[2] See section 399.26(d) of the Public Utilities Code (http://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=PUC&sectionNum=399.26.)
[3] For example, see section 6 of D.16-06-045 (http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M164/K214/164214092.PDF0
[4] Garver, *Effective Load Carrying Capability of Generating Units*. 1966 IEEE

This effect is illustrated in Figure 1, which shows the results of one particular ELCC analysis performed by E3. It demonstrates that ELCC can account for the fact that a portfolio of resources may yield higher total ELCC than the application of ELCC to specific resource classes individually. This proposal calls the additional capacity value of the portfolio above the sum of the capacity value of the component parts the diversity benefit. In this case, the diversity benefit results partly from the fact that solar generation tends to push reliability problems later in the day when wind generation is more likely to be generating.[5]

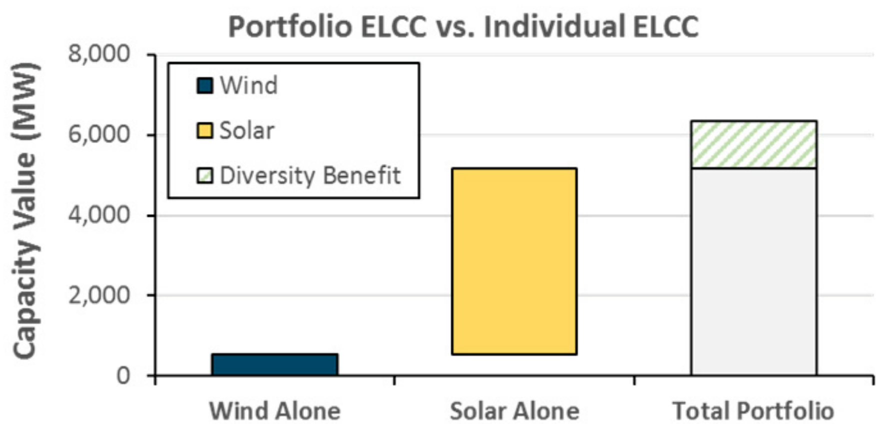


Figure 1. Portfolio ELCC vs. Individual ELCC – example of interactive effects.

Saturation is illustrated in Figure 2. ELCC can capture the fact an additional capacity increment of a resource may yield lower capacity value than the first capacity increments of the same resource, e.g., when solar is initially added to a system, it is generally correlated with peak load and has correspondingly high capacity value, but as solar generation fills traditional peak afternoon hours, its impact on system peaks (net of solar generation) and hence its capacity value diminishes.

[5] Or alternatively: the wind generation has moved some of the net peak load into the day, increasing the capacity value of the solar generation. One can already see that it is not straightforward to allocate the diversity benefit to either resource type.

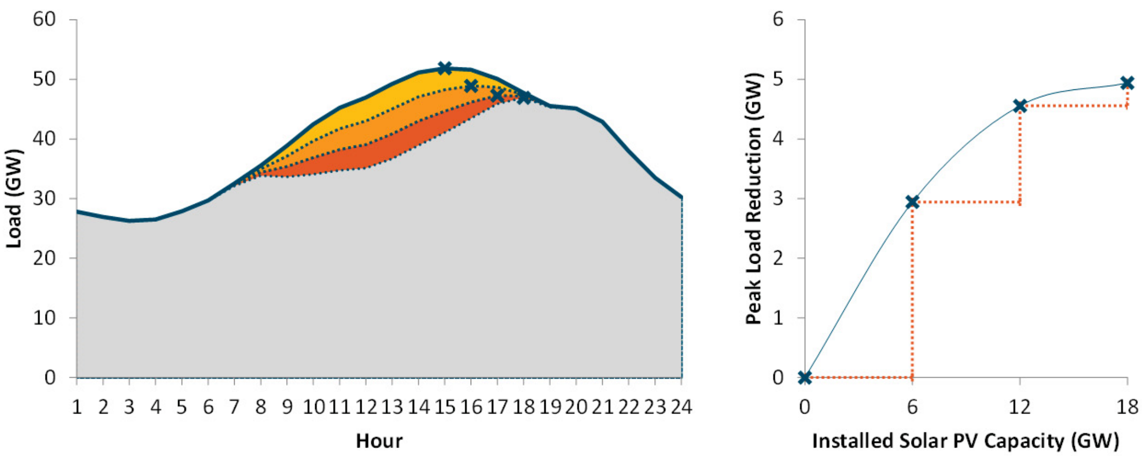


Figure 2. Example of negative interactive effects between variable resources: the diminishing marginal peak load impact of solar

1.3. Comparison of ELCC and Exceedance

E3 compared ELCC and exceedance estimates for the 2018 RA year for all wind and solar resources (including behind-the-meter (BTM) PV) in CAISO. Portfolio ELCCs were estimated using E3's RECAP model and load and renewable profiles developed by E3. The RECAP model has been used by the Commission for RPS planning, Long-Term Procurement Planning, Net Energy Metering evaluation, CSI cost-effectiveness, and has been formally adopted for calculating the capacity contribution of energy efficiency and demand response programs.[6] The model, including load and renewable profiles, is publicly available on E3's website.[7] E3 relied on its own profiles because Energy Division's (ED's) profiles were not available at the time of analysis.[8] The profiles are summarized in the following table.

Type	Weather Record	CF	2016 GWh	2018 GWh	2018 MW	Notes
Load	1950-2012	-	223,117	221,877	45,604	Created by neural network developed by E3. Scaled to 2018 energy and peak forecast, which is consistent with latest RPS calculator inputs (v6.2)

[6] http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M163/K338/163338441.docx
[7] https://ethree.com/public_projects/recap.php
[8] E3 also conducted preliminary analysis using the profiles that ED recently publicly posted. This analysis suggests that ED's renewable profiles yield similar results to E3's in combination with E3's load profiles. ED's profiles seem to yield lower ELCCs in combination with ED's load profiles, perhaps in part due to the treatment of Daylight Savings Time in the ED load profiles. Calpine does not have a strong preference on which profiles should be used to develop NQCs for RA compliance as long as they are error-free and based on reasonable assumptions.

Wind	2007-2012	30%	13,729	14,895	5,592	Created using NREL's Wind Toolkit wind speed data and E3 algorithm that applies power curves and hub heights depending on vintage.**
Utility Scale PV	2005-2012	24%	15,199	19,775	9,257	Created by aggregating NREL generation profiles based on the System Advisor Model (PVWatts).**
BTM PV	2005-2012	19%	6,708	8,636	5,072	Created by aggregating NREL generation profiles based on the System Advisor Model (PVWatts).**
Solar Thermal	2006-2012	29%	2,736	2,746	1,077	Created using NSRDB solar data and NREL's System Advisor Model. **

** All other inputs such as thermal generation are consistent with public RECAP version. Solar shapes were updated to obtain an overlapping set of weather years (2006-2012). This was necessary because NQC calculations require a matching set of renewable profiles (same weather year) in order to capture the diversity benefits correctly.*

*** Delivered energy is consistent with latest RPS calculator results (v6.2). Capacity is derived from shape's capacity factor.*

The calculation of ELCC involves calibrating a model to achieve a target level of reliability measured in terms of Loss of Load Expectation (LOLE). LOLE is the sum across hours of the Loss of Load Probability (LOLP) in each hour and is typically denominated in expected hours of lost load in a year, i.e., the number of hours in a year in which load is expected to exceed available generation and import capability. ELCC is then calculated by adding a resource or portfolio of intermittent resources to the model and adding flat blocks of load (or equivalently subtracting "perfect" generating capacity) until the model returns to the starting LOLE.

E3 assumed a target Loss of Load Expectation (LOLE) of 1 day in a 10 year period (1-in-10 standard). On an annual level, this corresponds to an LOLE of 2.4 hours. For the monthly ELCC calculations, the target LOLE was allocated equally to each month, resulting in a monthly LOLE target of 1/12th of the annual LOLE target, or 0.2 hours.

As shown in Figure 3, the exceedance methodology significantly overvalues the capacity value of the California renewable portfolio in the summer months. It results in capacity values of about 8,500 MW to 11,500 MW in May-September, while the more accurate ELCC methodology (using the same renewable profiles), results in capacity values of about 6,100 MW to 8,400 MW, a difference of up to 3,100 MW.

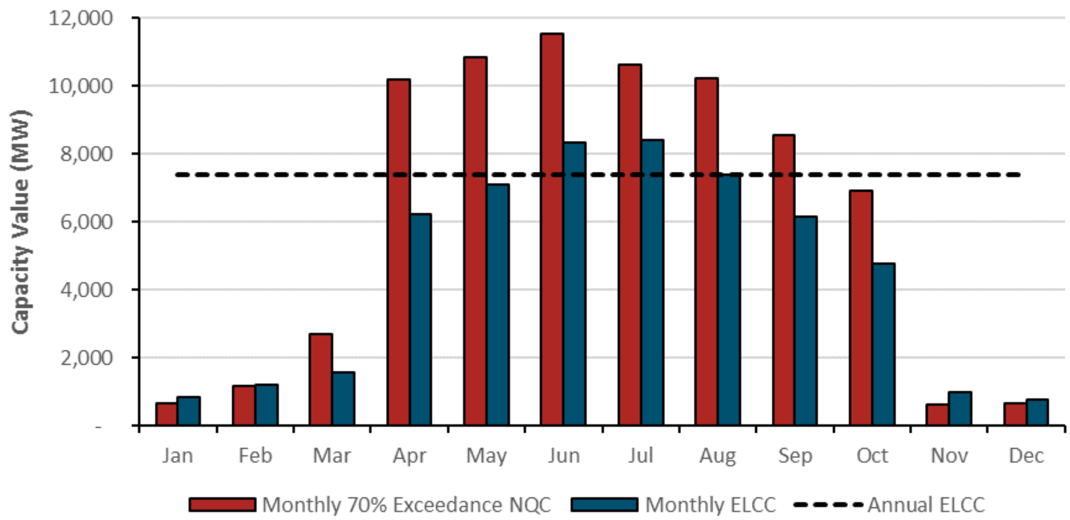
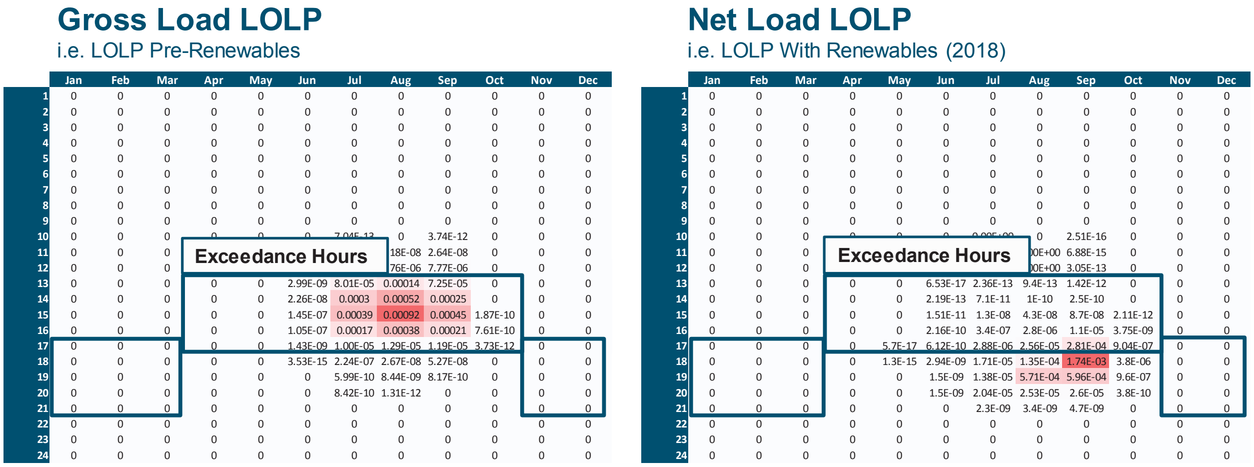


Figure 3. Monthly exceedance-based NQC compared to monthly and annual ELCC for the 2018 portfolio.

These results reflect the fact that the current exceedance approach fails to reflect performance in the hours that matter the most for reliability. This point is illustrated in Figure 4, which shows the timing of LOLP in 2 hypothetical systems. The left side of Figure 4 reflects a CAISO system without wind and solar. The right side of Figure 4 reflects a CAISO system with the penetrations of wind and solar expected in 2018. (Both hypothetical systems have been calibrated to the same LOLE standard so that they are equivalently reliable.)

The figure shows that while the exceedance approach captures performance in the hours with the highest LOLP in the absence of wind and solar, generally traditional afternoon peak hours, it does not capture performance in the highest LOLP hours for a system with high penetrations of wind and solar. In particular, the high expected solar penetration in 2018 pushes LOLP later in the day and towards the end of the summer. This shift diminishes the capacity value of solar resources in particular.



Gross Load LOLP (i.e. LOLP Pre-Renewables)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	[illegible]	[illegible]	[illegible]	7.04E-13	0	3.74E-12	0	0	0
11	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	18E-08	2.64E-08	0	0	0
12	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	76E-06	7.77E-06	0	0	0
13	0	0	0	0	0	2.99E-09	8.01E-05	0.00014	7.25E-05	0	0	0
14	0	0	0	0	0	2.26E-08	0.0003	0.00052	0.00025	0	0	0
15	0	0	0	0	0	1.45E-07	0.00039	0.00092	0.00045	1.87E-10	0	0
16	0	0	0	0	0	1.05E-07	0.00017	0.00038	0.00021	7.61E-10	0	0
17	0	0	0	0	0	1.43E-09	1.00E-05	1.29E-05	1.19E-05	3.73E-12	0	0
18	0	0	0	0	0	3.53E-15	2.24E-07	2.67E-08	5.27E-08	0	0	0
19	0	0	0	0	0	0	5.99E-10	8.44E-09	8.17E-10	0	0	0
20	0	0	0	0	0	0	8.42E-10	1.31E-12	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0

Net Load LOLP (i.e. LOLP With Renewables (2018))

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	[illegible]	[illegible]	[illegible]	0.00E+00	0	2.51E-16	0	0	0
11	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	00E+00	6.88E-15	0	0	0
12	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	00E+00	3.05E-13	0	0	0
13	0	0	0	0	0	6.53E-17	2.36E-13	9.4E-13	1.42E-12	0	0	0
14	0	0	0	0	0	2.19E-13	7.1E-11	1E-10	2.5E-10	0	0	0
15	0	0	0	0	0	1.51E-11	1.3E-08	4.3E-08	8.7E-08	2.11E-12	0	0
16	0	0	0	0	0	2.16E-10	3.4E-07	2.8E-06	1.1E-05	3.75E-09	0	0
17	0	0	0	0	5.7E-17	6.12E-10	2.88E-06	2.56E-05	2.81E-04	9.04E-07	0	0
18	0	0	0	0	1.3E-15	2.94E-09	1.71E-05	1.35E-04	1.74E-03	3.8E-06	0	0
19	0	0	0	0	0	1.5E-09	1.38E-05	5.71E-04	5.96E-04	9.6E-07	0	0
20	0	0	0	0	0	1.5E-09	2.04E-05	2.53E-05	2.6E-05	3.8E-10	0	0
21	0	0	0	0	0	0	2.3E-09	3.4E-09	4.7E-09	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4. 2018 Loss-of-Load Probability by month-hour with and without the 2018 renewable portfolio. All NQC hours are shown in standard time (PST); Table reflects annual ELCC results.

1.4. Impact of LOLE on ELCC

E3 investigated the sensitivity of its ELCC results to the target LOLE. Figure 5 and Table 2 summarize Calpine/E3's 2018 portfolio ELCC results at different levels of LOLE. The results show that the ELCC increases as the LOLE target increases. While there is a relatively large increase of ELCC at very low LOLE values, ELCC does not vary significantly around common LOLE targets, such as the proposed target of 2.4 hours per year.[9]

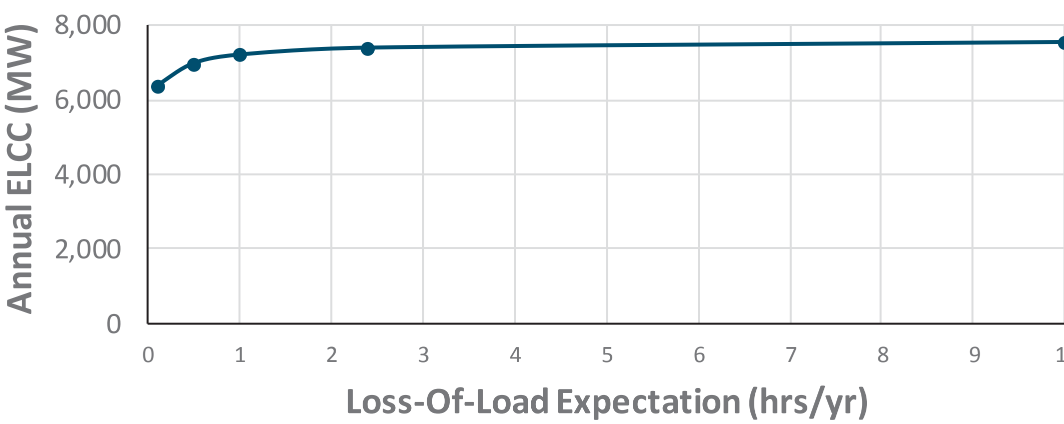


Figure 5. Annual ELCC as a function of target Loss-Of-Load Expectation (expressed in hours of lost load per year).

[9] This sensitivity analysis is also described in Calpine's December 1, 2016 comments.

Monthly ELCC (MW) by Annualized LOLE (hrs/yr)					
LOLE (hrs/yr)	0.1	0.5	1	2.4	10
All Months (MW)	6,350	6,953	7,187	7,374	7,525
Jan (MW)	744	789	814	852	923
Feb (MW)	1,043	1,124	1,155	1,190	1,263
Mar (MW)	1,511	1,541	1,558	1,583	1,644
Apr (MW)	5,086	5,440	5,746	6,237	5,609
May (MW)	6,694	6,961	7,059	7,079	7,210
Jun (MW)	7,971	8,196	8,259	8,326	8,262
Jul (MW)	7,660	7,932	8,136	8,420	8,499
Aug (MW)	6,640	6,955	7,123	7,367	7,758
Sep (MW)	5,321	5,668	5,864	6,150	6,452
Oct (MW)	4,046	4,274	4,535	4,764	4,794
Nov (MW)	1,017	1,001	991	972	934
Dec (MW)	704	824	837	786	798

Table 2. Monthly ELCC as a function of annualized target LOLE.

2. The Calpine/E3 Proposal

Building on the analysis summarized in the previous section, the Calpine/E3 Proposal articulates the specific steps involved in translating ELCC analysis into NQCs that are suitable for RA compliance. The proposal involves three main steps:

1) Calculating the ELCC of the entire portfolio of wind and solar resources ("Portfolio ELCC")
2) Disaggregating the Portfolio ELCC into Resource Class ELCCs.
3) Deriving NQCs for specific resources by allocating Resource Class ELCCs to specific resources in proportion to each resource's historical generation during a specific time window (or proxies in the case of resources with insufficient operating histories).

These steps are summarized in Figure 6.

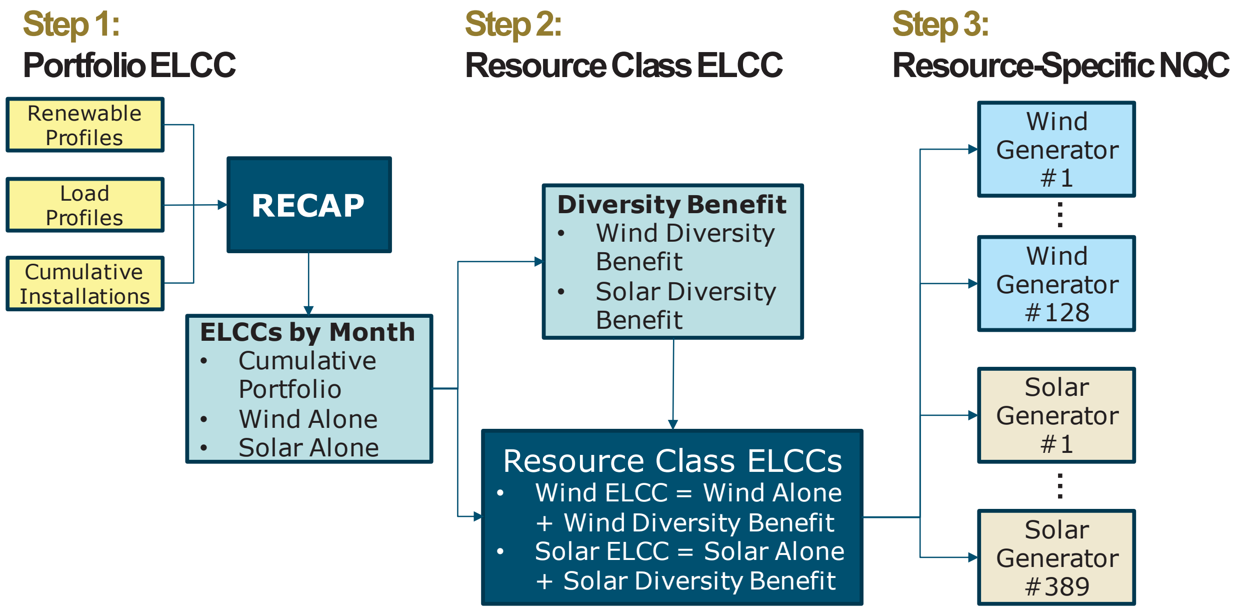


Figure 6. Flowchart of the ELCC proposal for existing resources.

2.1. BTM PV

The proposal treats behind-the-meter (BTM) PV as part of the solar portfolio for steps 1 and 2. It is important to include BTM PV in the ELCC modeling because it is a significant fraction of all solar generation and influences the ELCC of other resources, e.g., it increases the saturation of solar and hence lowers ELCC for all solar resources. Below, we provide an approach to account for BTM PV that is consistent with the current RA framework. BTM PV currently impacts RA requirements through its impact on the load forecasts used to set RA requirements. This proposal removes this impact from the solar Resource Class ELCC available to allocate to supply side resources to ensure that BTM PV is not double-counted both as supply and through its impact on RA requirements.

2.2. Vintaging

For 2019 and beyond, the proposal includes an approach to vintaging.[10] Vintaging entails calculating NQCs differently for resources that come on line at different times. Note that because this proposal treats all resource on-line in 2018 and before as part of the same vintage, <u>this portion of the proposal is not relevant to the implementation of ELCC in 2018</u>. Vintaging captures the fact that incremental procurement of intermittent resources may contribute differently to reliability than the average ELCCs calculated for 2018 and allocated to specific resources in steps 1-3 might reflect.[11] Reflecting a resource's incremental contribution to reliability in RA counting is important for a number of reasons.

[10] The proposal assumes that vintaging would treat all 2018 existing and planned resources as a single vintage and the resources that come on-line in each subsequent year as distinct vintages. The Commission may choose to split resources 2018 existing and planned resources into separate vintages, in which case vintaging would be necessary for 2018 as well.

[11] This effect is illustrated in Figure 2.

First, it aligns RA counting with appropriate long-term procurement signals. There is general agreement that capacity valuations in long-term procurement should reflect resources' incremental contribution to reliability. However, through its oversight of LCBF valuation methodologies, the CPUC can force only the IOUs to consider incremental rather than average capacity value in long-term procurement. The CPUC does not have similar oversight of other LSEs' procurement. Other LSEs likely will consider the RA compliance value of a resource in valuing the capacity associated with the long-term procurement of renewable resources. If the RA compliance value of a resource reflects its average rather than incremental contribution to reliability, LSEs may be encouraged to procure resources with comparatively high average NQCs without considering how their procurement may diminish the capacity value of other existing resources. This concern is especially important in light of recent patterns of load migration. Procurement by new LSEs, such as CCAs, may be ascribed inappropriately high NQCs and diminish the capacity value of existing resources in the IOUs' RPS portfolios if it is ascribed NQCs based on average rather than incremental contribution to reliability, resulting in economically inefficient procurement and raising competitive and cost-recovery concerns.

The vintaging approach in this proposal involves an iterative application of the steps described above to each vintage. In each year, steps 1-3 would be applied to the 2018 vintage. Then, NQCs would be derived for each subsequent vintage using steps 1-3 but with modified ELCC analyses that include resources from each previous vintage. For example, in 2020 the proposal would involve three separate sets of ELCC analyses: one to determine the NQCs of 2018 vintage resources, another to determine the NQCs of 2019 vintage resources (reflecting incremental ELCC relative to a portfolio that includes 2018 vintage resources), and a third to determine the NQCs of 2020 vintage resources (reflecting incremental ELCC relative to a portfolio that includes both 2018 and 2019 vintage resources).

Given that the proposal does not involve vintaging for the 2018 RA year, this aspect of the proposal could be considered further in the RA proceeding next year

The rest of this section includes more detailed descriptions of each of the steps described above.

2.3. Description of Methodology for 2018

2.3.1. Calculate Portfolio ELCC

Step 1 calculates the ELCC of the entire portfolio of wind and solar resources ("Portfolio ELCC"). The implementation of the proposal summarized here relies on the Portfolio ELCC estimates described in Section 1.3 and summarized in Figure 3.

As discussed in Section 1.4, the choice of LOLE is a benchmark and does not generally materially impact results except at very low levels of LOLE i.e. high levels of reliability. Consequently, this proposal recommends deriving monthly ELCCs based on a flat 2.4 hours/year (0.2 hours/month) standard. This standard corresponds to one interpretation of the widely used 1-in-10, i.e., 1 day (24 hours)-in-10 years standard. In addition, the use of a common LOLE standard across all twelve months is simple and reflects the fact that the current RA program utilizes flat planning reserve margins across all twelve months and hence presumably targets comparable levels of reliability in different months (although the same planning reserve margin in different months may yield different levels of reliability.)

Installations (MW)

	Wind	Solar
Nameplate Capacity (MW)	5,592	15,406

Month	Portfolio ELCC (MW)
Jan	852
Feb	1,190
Mar	1,583
Apr	6,237
May	7,079
Jun	8,326
Jul	8,420
Aug	7,367
Sep	6,150
Oct	4,764
Nov	972
Dec	786

Figure 7. Calculation of Monthly Portfolio ELCC values for existing resources.

2.3.2. Calculate Resource Class ELCC

Step 2 derives Resource Class ELCCs by calculating standalone ELCCs for solar and wind and then adjusting them to reflect a diversity benefit.

Based on the same assumptions as Step 1, Step 2 calculates ELCCs for solar alone and wind alone, i.e. it models the ELCC of solar in a system that excludes wind and vice versa. These results are summarized in the following table.[12]

[12] Note that this disaggregation could be performed for more classes of resources. For example, separate class-specific ELCCs could be calculated for solar and wind in different locations or utilizing different technologies. In this proposal, we treat all wind, on the one hand, and all solar, on the other hand, as classes in part for tractability but also because Step 3 of the proposal reflects differences in the performance of specific resources within a class in assigning resource-specific NQCs.

Month	ELCC, Wind Alone (MW)	ELCC, Solar Alone (MW)	Portfolio ELCC (MW)
	[1]	[2]	[3]
Jan	853	-2	852
Feb	975	159	1,190
Mar	438	747	1,583
Apr	781	4,436	6,237
May	1,026	4,690	7,079
Jun	1,160	5,773	8,326
Jul	960	5,677	8,420
Aug	632	5,153	7,367
Sep	438	4,758	6,150
Oct	476	3,706	4,764
Nov	446	436	972
Dec	781	2	786

Table 3. ELCC results for Resources alone and the combined Portfolio; existing resources.

Portfolio ELCC is greater than the sum of the standalone ELCCs. This discrepancy is due to the diversity benefit described in Section 1.2. The diversity benefit is allocated to each Resource Class in proportion to its standalone ELCC. An example calculation for the month of July is illustrated in the following figure. The diversity benefit is estimated as the difference between the July portfolio ELCC of 8,420 MW and the sum of the standalone ELCCs (960 MW for wind and 5,677 MW for solar), which yields 1,783 MW. The 1,783 MW diversity benefit is then allocated to wind and solar in proportion to their standalone ELCCs of 960 MW and 5,677 MW.

For the reasons articulated above, the proposal treats BTM PV generation equivalently to other solar resources for the calculation of Portfolio and Resource Class ELCCs. As described below, the proposal adjusts solar Resource Class ELCC to account for the implicit impact of BTM on RA requirements through its impact on the load forecasts used to set RA requirements before allocating solar Resource Class ELCC to specific supply-side solar resources.

Outputs from RECAP (Wind Alone, Solar Alone, Portfolio ELCC)

Month	Wind Alone (MW) [1]	Solar Alone (MW) [2]	Portfolio ELCC (MW) [3]	Diversity Benefit (MW) [4] = [3]–[2]-[1]
Jan	853	-2	852	1
Feb	975	159	1,190	55
Mar	438	747	1,583	398
Apr	781	4,436	6,237	1,019
May	1,026	4,690	7,079	1,363
Jun	1,160	5,773	8,326	1,394
Jul	960	5,677	8,420	1,783
Aug	632	5,153	7,367	1,582
Sep	438	4,758	6,150	954
Oct	476	3,706	4,764	581
Nov	446	436	972	91
Dec	781	2	786	3

$$\left(\frac{5{,}677}{5{,}677 + 960}\right) \times 1{,}783 + 5{,}677 = \boxed{\textit{Solar ELCC}\ \ 7{,}201\text{ MW}}$$

47% of nameplate solar capacity

$$\left(\frac{960}{5{,}677 + 960}\right) \times 1{,}783 + 960 = \boxed{\textit{Wind ELCC}\ \ 1{,}218\text{ MW}}$$

22% of nameplate wind capacity

Figure 8. Calculation of the Diversity Benefit and the Resource Class ELCC for existing resources.

2.3.3. Calculate resource-specific NQCs

To determine resource-specific NQCs suitable for use in RA compliance, the proposal allocates Resource Class ELCCs to individual resources in proportion to their performance in a predefined time window. This aspect of the proposal mirrors the current exceedance approach in that it relies on historical data for resources with a performance history or proxy data for new resources without a history. Calpine/E3 recommend basing the allocation on performance during a broad set of peak load hours, which is a rough proxy for the hours when LOLP is likely highest and hence are most relevant to the determination of a resource's ELCC. Based on the pattern of LOLP shown in Figure 4, we use performance during HE 14–HE 20 (standard time) in the summer and HE 14–HE 21 (standard time) during the winter to allocate Resource Class ELCC to specific resources. The proposal uses a time window based in part on LOLP from a system *without* renewables to assign value to the resources that are responsible for shifting the peak. It also uses a time window based in part on LOLP from a system *with* renewables to assign value to resources that are responsible for reducing the peak and providing reliability in the 2018 system.

The proposal differentiates between the NQCs of resources within the same Resource Class based on a comparatively simple method. This strikes a balance between the computational complexity of formally modeling the ELCC of each specific resource, and the approximation of assigning a class average ELCC-based NQC to every resource. In addition, by linking a resource's NQC to its actual output, the proposal provides an incentive for resources to perform.

Calpine/E3 do not have access to the detailed resource-specific data that would be necessary to perform Step 3, but an illustrative example of how Step 3 might be implemented is provided in the following figure. For the month of July, each resource's output during the time window is measured and divided by the sum of all the resources' output to yield a percentage; this percentage is then multiplied by the Resource Class ELCC to determine resource-specific NQC.

Resource specific NQCs sum up to the total July solar Resource Class ELCC of 7,201 MW.

Resource specific NQCs sum up to the total July Resource Class wind ELCC of 1,218 MW.

Solar ELCC

Project	Nameplate Capacity (MW)	Output During Peak Period (MWh)	% of Total Solar Output in July	Resource Specific NQC - July (MW)	Resource Specific NQC-July (% of Nameplate)
1	17	4,874	0.12%	9	53%
2	45	10,769	0.27%	20	44%
3	50	11,160	0.28%	20	41%
⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮
389	4	911	0.02%	2	42%
Totals	**15,406**	3,921,739	100%	7,201	**47%**

Wind ELCC

Project	Nameplate Capacity (MW)	Output During Peak Period (MWh)	% of Total Wind Output in July	Resource Specific NQC - July (MW)	Resource Specific NQC - July (% of Nameplate)
1	24	1,684	0.54%	7	28%
2	13	671	0.22%	3	21%
3	59	3,339	1.07%	13	22%
⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮
128	46	3,044	0.98%	12	26%
Totals	**5,592**	310,723	100%	1,218	22%

This is the total solar generation during all the peak hours in July

The % of total solar output is the proportion of solar Resource Class ELCC that gets allocated to this particular generator

Figure 9. Calculation of Project ELCC for existing resources.

Calpine/E3 believe that Step 3 could be implemented through a relatively minor modification to the methodology that Energy Division currently uses to calculate NQCs using the exceedance methodology.[13]

BTM PV currently impacts RA requirements through its impact on the load forecasts that are used to set RA requirements. To facilitate implementation of ELCC, the proposal preserves this treatment, but in order to ensure that the aggregate of BTM and supply-side solar does not exceed the solar Resource Class ELCC, the proposal reduces the Resource Class ELCC available to allocate to supply-side resources by the indirect impact of BTM PV on RA requirements.[14] This reduction should reflect not only the direct impact of BTM PV on the load forecast but the planning reserve margin as well, i.e., if 1 MW of BTM PV reduces the peak load forecast by 1 MW, it reduces RA procurement obligations by 1.15 MW. This adjustment is illustrated in the following table.

[13] Alternatively, an allocation based on values calculated using the current exceedance methodology likely would yield similar results.

[1414] Alternatively, BTM PV could treated as resources. This approach would involve changing the load forecasts that are used to set RA requirements to remove the impact of BTM PV.

	GW
1) RA requirement based on gross load	48.0
2) RA requirement based on load net of BTM PV	46.0
3) Contribution of BTM PV (1-2)	2.0
4) Adjustment for PRM (3)*115%	2.3
5) Solar Resource Class ELCC	5.0
Solar Resource Class ELCC available for supply-side resources (5-4)	2.7

Table 4: Illustrative BTM Adjustment Calculation

2.4. Vintaging

The methodology outlined above is sufficient to derive ELCC-based NQCs for the 2018 RA year. If the Commission chooses not to implement vintaging, the same methodology could be used for the 2019 RA year and beyond. If the Commission implements vintaging, the following iterative approach would be used for the 2019 RA year and beyond.[15]

For each RA year, steps 1-3 would be applied to the 2018 vintage, i.e., the resources that operated in 2018. Then, NQCs would be derived for each subsequent vintage using steps 1-3 but with modified ELCC analyses that include resources from each previous vintage. For example, in 2020 the proposal would involve three separate sets of ELCC analyses: one to determine the NQCs of 2018 vintage resources, another to determine the NQCs of 2019 vintage resources, i.e., the resources that commence operation in 2019, reflecting incremental ELCC relative to a portfolio that includes 2018 vintage resources, and a third to determine the NQCs of 2020 vintage resources, i.e., the resources expected to commence operation in 2020, reflecting incremental ELCC relative to a portfolio that includes both 2018 and 2019 vintage resources.

The potential application of this approach is illustrated in this hypothetical example for a 2019 vintage estimated for the 2019 RA year.[16] Figure 10 shows the 2019 vintage portfolio in relation to the 2018

[15] Similar steps would be necessary if the Commission decides to split 2018 existing and planned resources into different vintages.

[16] In 2019, NQCs for the 2018 vintage would be calculated according to Steps 1-3 of this proposal, but presumably using updated load and renewable input assumptions. Similarly, the 2019 vintage results would be based on then current input assumptions. For the purposes of this example, we use the same input assumptions as we are using to develop 2018 NQCs, but for the 2019 vintage capacity additions reflected in the example.

vintage portfolio. It reflects the addition of 1,000 MW of supply-side PV, 1,000 MW of BTM PV, and 500 MW of wind, with the same profiles that were used to develop estimates of 2018 average NQCs.

2018 Existing Resources

	Wind (MW)	Solar (MW)	Combined (MW)
Cumulative Installations	5,592	15,406	20,998

In the 2018 case, ELCC is calculated relative to these values

2019 New Resources

	Wind (MW)	Solar (MW)	Combined (MW)
2018 Cumulative Installations	5,592	15,406	20,998
2019 Cumulative Installations	6,092	17,406	23,498
2019 Incremental Installations	500	2,000	2,500

In the 2019 case, ELCC is calculated relative to these values (marginal to the existing 2018 portfolio)

Figure 10. Comparison of existing and new portfolio.

The first three columns of Table 5 show the standalone ELCCs and Portfolio ELCCs of the 2019 vintage portfolio estimated by adding the resources to a system that already includes the 2018 vintage portfolio. The remaining columns show the calculation of the diversity benefit and class average NQCs as a fraction of nameplate for this incremental portfolio. Note that these class-average NQCs are **significantly** different from the average ELCCs for the 2018 vintage portfolio shown above, illustrating the important implications of vintaging.

2019 New Resources ELCC

			Portfolio		Resource Class 1	Resource Class 2	Resource Class 1	Resource Class 2
Month	Wind Alone ELCC (MW)*	Solar Alone ELCC (MW)*	Portfolio ELCC (MW)*	Diversity Benefit (MW)	ELCC allocation wind (MW)	ELCC allocation solar (MW)	ELCC allocation wind (%)	ELCC allocation solar (%)
	[1]	[2]	[3]	[4] = [3] - [2] - [1]	[5] = [1] + [1]/([1]+[2]) * [4]	[6] = [2] + [2]/([1]+[2]) * [4]	[7] = [5] / Wind Nameplate MW	[8] = [6] / Solar Nameplate MW
Jan	50	0	51	1	52	0	10%	0%
Feb	47	15	62	1	47	15	9%	1%
Mar	38	3	40	-1	37	3	7%	0%
Apr	133	101	237	3	135	103	27%	5%
May	159	97	258	2	160	98	32%	5%
Jun	193	200	400	7	196	204	39%	10%
Jul	223	209	436	4	225	211	45%	11%
Aug	167	157	328	4	169	159	34%	8%
Sep	104	138	246	3	105	140	21%	7%
Oct	83	91	174	0	83	92	17%	5%
Nov	29	0	29	-1	28	0	6%	0%
Dec	45	0	46	1	47	0	9%	0%

Table 5. Calculation of Diversity Benefit and Resource Class ELCC

3. Conclusion and Recommendations

Calpine/E3 believe that this proposal appropriately meets and balances different criteria with respect to the implementation of ELCC in the RA program.

1. **Goal: Ensuring reliability by accurately assessing the capacity contribution of the portfolio of wind and solar resources.**

   The proposal ensures reliability by implementing ELCC, ensuring that the NQC of all wind and solar resources are equal to their Portfolio ELCC in aggregate, and appropriately accounting for the impact on reliability of BTM PV.

2. **Goal: Ascribing NQCs that reflect the performance of specific resources.**

   The proposal captures the performance of different classes of resources by calculating separate Resource Class ELCCs. Within each resource class, the proposal rewards performance by assigning proportionally higher NQCs to resources with more favorable generation profiles.

3. **Goal: Accounting for the impact of behind-the-meter resources on ELCC estimates**

   The proposal appropriately accounts for the impact of BTM PV on ELCC estimates.

4. **Goal: Encouraging appropriate consideration of capacity value in the procurement of new renewable resources.**

   If the vintaging element of the proposal were implemented, new resources would be ascribed NQCs that reflect their incremental contribution to reliability, facilitating accurate capacity valuations of new resources by all LSEs, including those that are not necessarily required to use CPUC-mandated LCBF methodologies.

5. **Goal: Minimizing the computational and compliance burdens associated with calculating NQCs.**

   The proposal requires an ELCC analysis for the entire portfolio of wind and solar resources and standalone ELCC analyses for each Resource Class for 2018, i.e., 3 ELCC calculations per month or 36 in total. In the event that vintaging is implemented, the proposal would require the same number of analyses for each vintage as the proposal for 2018.

In light of how the Calpine/E3 Proposal scores against the diverse criteria articulated above, Calpine recommends that the Commission formally adopt the Calpine/E3 Proposal, particularly the following key elements:

(1) Estimates of the ELCC of the entire portfolio of wind and solar resources should define how such resources count towards RA requirements in aggregate.

(2) ELCC-based NQCs should be calculated by calculating Resource Class ELCCs, i.e., ELCCs for broad categories of resources such as wind and solar, and then allocating the Resource Class ELCCs to individual resources within a class based on their historical performance (or estimates of their performance in the case of new resources).

(3) Resource Class ELCC estimates should reflect but not double-count diversity benefits and sum to the Portfolio ELCC.

(4) For 2018, the Commission should rely on the estimates of Portfolio and Resource Class ELCCs in the Calpine/E3 Proposal or other estimates developed using another ELCC model, such as SERVM, and plausible input assumptions.

(5) The development of ELCC-based NQCs should account for the impact of BTM PV. Calpine/E3 recommend adjusting downward the amount of solar Resource Class ELCC available to allocate to supply-side resources by an estimate of the indirect impact of BTM PV on RA requirements through its impact on the load forecasts used to set RA requirements, including appropriate consideration of the planning reserve margin.

In addition, for 2019 and beyond, the Commission should consider implementation of the vintaging approach described in Section 2.2.